

# The Red-whiskered Bulbul *Pycnonotus jocosus* in Australia – a global perspective, history of introduction, current status and potential impacts

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## ABSTRACT

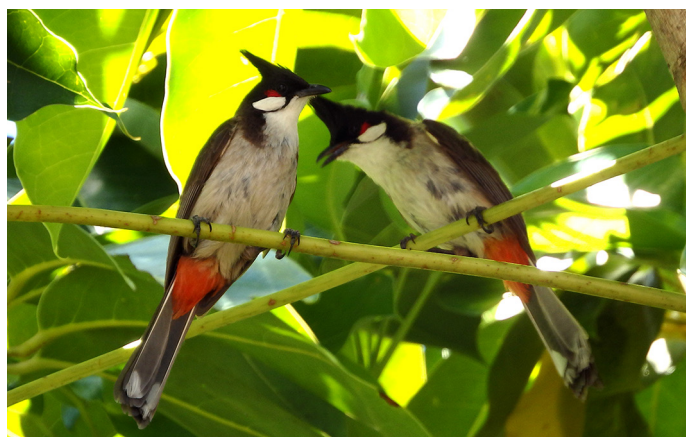
The Red-whiskered Bulbul *Pycnonotus jocosus* naturally occurs from the Indian subcontinent to the northern Malay Peninsula. Its anthropogenic spread also encompasses Australia, Japan, the southern Malay Peninsula, Singapore, Florida, California, 11 islands in the Indian Ocean, and Oahu, Hawaii. The earliest known introduction occurred in Sydney in 1865, with subsequent releases in the 1900's leading to establishment. It was first released in Melbourne, Victoria in 1915, with a population establishing in the late 1950's. Sightings have been reported in Coffs Harbour since 1972, forming a population in the Northern Rivers region. There has also been a small population in Mackay, Queensland since 1983. Red-whiskered Bulbuls had been recorded in South Australia between the 1940's and 1980's, but did not proliferate and are no longer present. The main ecological impact identified is the dispersal of exotic weeds, although evidence in Australia remains anecdotal. There has also been preliminary evidence of interspecific competition on islands and predation of nestlings. While aesthetically appreciated and a predator of some invertebrate pests, it causes crop failure in soft-fruit and citrus orchards and damage to garden plants. Impacts should be further investigated to justify management directions. Eradication in Australia may be achievable due to populations being mostly restricted to settled areas.

**Key words:** aviary escapes, cage-bird, invasive species, naturalisation, Pycnonotidae

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## Introduction

Over 100 species of bulbuls (Pycnonotidae) have been described. These occur across most of Africa, islands of the Indian Ocean, the Middle East, and Asia. At least four species have had significant anthropogenic spread (Lever 2010), including the Red-whiskered Bulbul *Pycnonotus jocosus* (Fig. 1). In Australia and other parts of the world, invasive species present a concern for potential ecological impacts, including alteration of vegetation communities, and competition and displacement of native fauna (e.g., Bleach *et al.* 2014; Cooke 2014; Grarock *et al.* 2014; Mutze *et al.* 2014; Old *et al.* 2014).



**Figure 1.** A breeding pair of Red-whiskered Bulbuls *Pycnonotus jocosus* in Sydney, Australia. Photo, M. Mo.

The Red-whiskered Bulbul is one of two species of bulbul brought to Australia (Le Souëf 1918; Barrett *et al.* 2003; Higgins *et al.* 2006), and the only one that has remained established. It is a distinctive-looking bird, unmistakable among Australian avifauna; the black crest stands erect except in flight, and a red earmark contrasts with the white cheek patches, giving the species its name (Pizzey *et al.* 2007). The species has also been erroneously identified as the Red-vented Bulbul *P. cafer*, the second species known to have been released in Australia (Le Souëf 1918); the descriptions provided by at least one of these authors (Terrill 1946) indicate their subject to being the Red-whiskered Bulbul.

This paper synthesises information on the Red-whiskered Bulbul in Australia. The aims of this review were:

- to provide background on global introductions of the Red-whiskered Bulbul;
- to examine available information on the history of introductions in Australia and the current status of established populations;
- to examine known ecological impacts in Australia, as well as these in other naturalised locations that may arise in Australia; and
- to examine social impacts in Australia

This review forms an informative basis for assessing the

current status of the Red-whiskered Bulbul in Australia and its impacts. It also provides direction for future research and species management.

## Ecology of the Red-whiskered Bulbul

### Natural distribution and habitat

The Red-whiskered Bulbul naturally occurs from the Indian subcontinent and southern China, south to northern Malay Peninsula (Ali and Ripley 1971; Long 1981; de Schauensee 1984; Sibley and Monroe 1990; Grimmett *et al.* 1999; Fig. 3). The countries within this distribution include Nepal, Bangladesh, Bhutan, Burma (Myanmar), Cambodia, Laos, Malaysia, Vietnam, and Thailand (Robson 2002; Lever 2010; BirdLife International 2015). Populations also occur on the Andaman Islands and Hong Kong (del Hoyo *et al.* 2005; Sivaperuman and Venkataraman 2012).

Habitat preferences are strongly associated with open wooded environments, especially well-watered areas (Robson 2002; Techachoochert and Round 2013). The Red-whiskered Bulbul inhabits open forest, woodland, agricultural land, especially cultivation and orchards, and urban areas (Ali and Ripley 1971; de Schauensee 1984; Xiaohua 1992; Chafer *et al.* 1999; Grimmett *et al.* 1999). Dense vegetation is apparently avoided; however, it may occur in secondary growth (Robson 2000). Where naturalised, it is often found in areas infested with berry-producing weeds, such as lantana *Lantana* spp., Blackberry Bramble *Rubus fruticosus*, privet *Ligustrum* spp., African Olive *Olea europaea*, coral trees *Erythrina* spp., and asparagus fern *Asparagus* spp. (Gibson 1977; Morris 1986; Leishman 1994; Wood 1995; pers. obs).

### Diet and feeding

The Red-whiskered Bulbul has a flexible diet, exploiting a wide range of fruits and incorporating nectarivory, and fly-catching (Carleton and Owre 1975; Xiaohua 1992;



**Figure 2.** A Red-whiskered Bulbul *Pycnonotus jocosus* nest containing two nestlings in Sydney, Australia. Note, the use of plastic in the structure of the nest. Photo, M. Mo.

Linnebjerg 2010). This has apparently been a significant factor for survival in areas of seasonal fruit abundance (Corlett 1998). Fruits are taken from the canopy and shrubbery (MacPherson 1923; Gosper 1999). On rare occasions, it has been observed gathering fallen fruit and foraging in leaf litter (Gannon 1932; Bird Observers Club Australia, unpubl. data). The Red-whiskered Bulbul is an important seed disperser (Corlett 1998; Eguchi and Amano 2004; Mandon-Dalger *et al.* 2004; Linnebjerg *et al.* 2009, 2010). Other plant materials consumed include flowers (Gannon 1932; Gilbert 1939), leaves, and buds (Higgins *et al.* 2006). In a study in southern China, plant materials comprised approximately 65 percent of the diet (Xiaohua 1992). In contrast, fruits comprised almost 99 percent of the diet in Mauritius (Linnebjerg *et al.* 2010).

The Red-whiskered Bulbul preys on arthropods such as cicadas (Cicadidae; Rose 1999), flies (Diptera; Chisholm 1933), aphids (Aphididae; MacPherson 1921, 1924), ants and their larvae (Formicidae; Chisholm 1933; A.J. Leishman, unpubl. data), moths and their larvae



**Figure 3.** Global distribution of the Red-whiskered Bulbul *Pycnonotus jocosus*. Legend: black = natural range; grey = naturalised range.

(Lepidoptera; Chaffer 1933; Chisholm 1933; Frith 1979; Gregory-Smith 1983), and golden orb-weaving spiders *Nephila* spp. (Islam and Williams 2000). Xiaohua (1992) found arthropods comprising approximately 28 percent of the diet in southern China. These are either taken in mid-air (Gannon 1932; Chaffer 1933) or gleaned from vegetation (MacPherson 1921, 1924). There were also inferences of attacks on the nestlings of other species (Roberts 1988; Philippe and Mandon-Dalger 2001; Baker *et al.* 2014). However, whether or not the motivation was predation was not clear.

## Breeding

The timing of the breeding season varies geographically; March to July in northern India, December to June in southern India (Ali and Ripley 1971), February to August in southern China (Xiaohua 1992) and Hawaii (van Riper *et al.* 1979), and July to January on the Macarene Islands (Amiot *et al.* 2007). In Australia, there have been no detailed studies. There have been records of fledglings observed in all months except April and June (Blakers *et al.* 1984; Barrett *et al.* 2003; Higgins *et al.* 2006). Other stages of breeding have been observed from September to February (Chaffer 1933; Morris *et al.* 1981; Barrett *et al.* 2003).

Nests are shaped as shallow open cups usually located in dense foliage (Fig. 2; Beruldsen 2003). Nest materials include twigs, bark, grass, leaves, fine roots and spider silk, as well as non-natural materials such as paper, plastic, wool and string (Chaffer 1933; van Riper *et al.* 1979; Beruldsen 2003). In some studies, nest-building and incubation was carried out solely by the female (Xiaohua 1992). Elsewhere, these duties have been shared between both partners (Ali and Ripley 1971). In breeding pairs observed in Sydney, one individual brought the nest material and built, while its partner accompanied from a nearby perch (pers. obs). Clutch sizes range from two to five eggs, and a breeding pair may produce three clutches per year (Barker 1932; Barrington 1985). Incubation lasts for 10 to 14 days, after which fledging occurs 10 to 12 days after hatching (Ali and Ripley 1971; van Riper *et al.* 1979; Xiaohua 1992). Both partners fly close to nest predators, calling vigorously to form a distraction, and share in feeding the chicks (Barrington 1985; Xiaohua 1992; pers. obs).

## Global introductions

### Asia

The Red-whiskered Bulbul is a popular cage-bird in many Asian countries (Philippe and Mandon-Dalger 2001; Techachoochert and Round 2013). It has been introduced to Japan (Eguchi and Amano 2004; Fig. 3), where the population has been estimated to be 100 to 10 000 breeding pairs (Brazil 2009). There have also been records in the cities of Dubai and Abu Dhabi in the United Arab Emirates (Fig. 3), including observations of breeding (Lever 2010). The Red-whiskered Bulbul has also reached southern Malay Peninsula and Singapore (Hails 1987; Robson 2000; Fig. 3). Some authors suggest that populations have established in Java and Sumatra

(Medway and Wells 1976; Long 1981; van Marle and Voous 1988). No supporting data were provided.

### North America

The naturalised population in Florida (Fig. 3) is perhaps one of the most documented invasions of the Red-whiskered Bulbul. The source of this population originated from individuals that escaped during an aviary transfer in a bird farm in Kendall in 1960 (Stimson 1962; Fisk 1966; Owre 1973). The number of escapees was either five to 10 breeding pairs (Carleton and Owre 1975) or five to 10 individuals (Robertson and Woolfenden 1992). The first known successful breeding attempt was recorded in 1961 (Owre 1973). There have been claims that the population had reached 500 individuals by 1973 (Rand 1980) and up to 700 by the 1980's (Holt 1989). No supporting data were provided. The current range of this population is estimated to be 41.7 square km of urban area in the suburbs of Kendall and Pinecrest (Pranty 2010). Reluctance to spread rapidly was attributed to attachment to communal roosts (Fisk 1966).

Red-whiskered Bulbuls in California (Fig. 3) were established from aviary escapees around 1968 (Clark 1976; Lever 2010). An active eradication program collected 47 individuals in the first three years since detection (Los Angeles County Department of Agriculture, unpubl. data). Two populations persist around the vicinities of the Los Angeles County Arboretum and Botanical Garden, Arcadia and Huntington Botanical Gardens, San Marino (Hardy 1973; Lever 2010).

### Islands of the Indian Ocean

The Red-whiskered Bulbul has also invaded a number of islands in the Indian Ocean (Fig. 3). It has become one of the most successful invasive species on two of the Macarene Islands, Réunion Island (Mandon-Dalger *et al.* 1999, 2004; Clergeau and Mandon-Dalger 2001; Amiot *et al.* 2007) and Mauritius (Linnebjerg *et al.* 2009, 2010). Up to six pairs were imported to Port Louis, Mauritius in 1892, spreading throughout the island by 1910 (Cheke 1987; Lever 2010). The population that was established in Mayotte in the southern Comoros Islands was apparently sourced from Mauritius (Louette 1999; R.J. Safford, unpubl. data). Bertrand (2000) reported a population in Juan de Nova, an island off the west coast of Madagascar.

Deliberate releases were carried out in Camorta, Nicobar Islands in the late 1800's using stock from the Andaman Islands (Sankaran and Vijayan 1993; Sankaran 1998). The Nicobaris further introduced the Red-whiskered Bulbul onto the islands of Nancowry, Trinkat, Katchall, Teresa and Car Nicobar. Releases in Katchall may have occurred later in the 1910's (Sankaran 1998).

A consignment of six Red-whiskered Bulbuls from Mauritius was released on the island of Assumption, one of the Seychelles Islands in 1977 (Michel 2015). Despite calls for control measures, the population grew to several thousand over the next 30 years (Roberts 1988; Hill and Currie 2007). It was successfully eradicated between 2013 and 2015 by mist-netting and shooting (Bunbury *et al.* 2013; Michel 2015).

## Oahu, Hawaii

The Red-whiskered Bulbul was first recorded in Oahu, Hawaii in 1965 (Berger 1975; Williams 1983). It now occurs in a pocket on the southeastern part of the island (Fig. 3), largely confined to moist urban areas. The importation of exotic fruiting trees proliferated population spread (Neal 1965; van Riper *et al.* 1979). Its distribution in 1982 (Williams and Giddings 1984) was much the same as in 1977 (van Riper *et al.* 1979). Range expansion was thought to be slower in comparison to the Red-vented Bulbul, also introduced there, due to difficulties dispersing between suitable habitats on the heads of valleys (Williams and Giddings 1984).

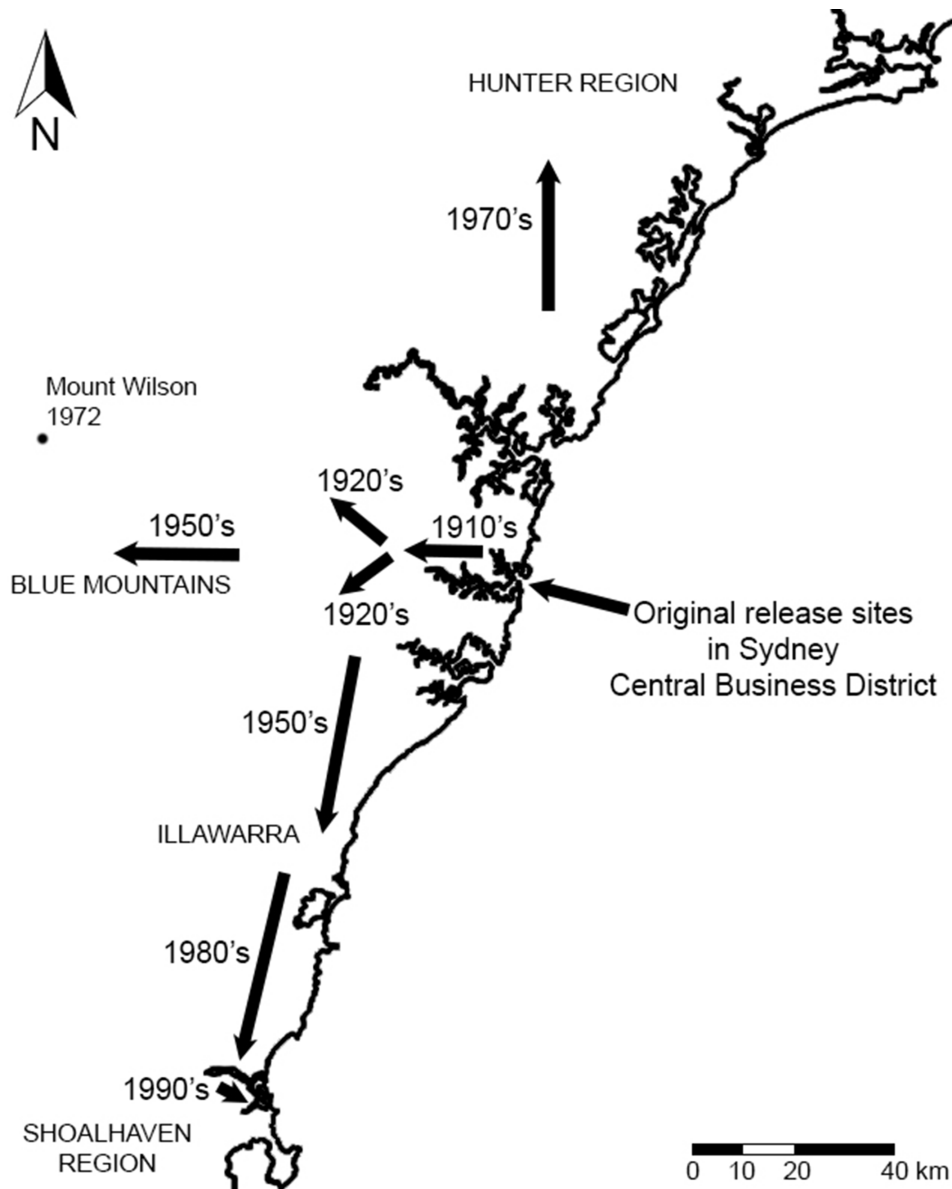
## Introduction to Australia

### Greater Sydney Region, New South Wales

In 1865, ten living birds in a shipment of 66 Red-whiskered and Red-vented Bulbuls survived to arrive in Sydney

(Fig. 4). These were kept in an aviary in the Sydney Botanic Gardens (Higgins *et al.* 2006). The second known importation occurred in 1880 (Tarr 1950; Long 1981; Smith and Smith 1990); Red-whiskered Bulbuls imported from China by the Zoological and Acclimatisation Society were released, but did not appear to survive (Lever 2010).

Introduction attempts continued into the 20th Century with better success. There were reports of Red-whiskered Bulbuls sighted in the Eastern Suburbs (e.g., Double Bay in 1917 and 1923), Inner West (e.g., Homebush in 1902, Ashfield in 1914) and Northern Suburbs (e.g., Wahroonga in 1921) (Wolstenholme 1921; MacPherson 1923; Chisholm 1926; Long 1981; Tarr 1950; Lever 2010). The first known observation of breeding occurred in Hunters' Hill in 1919 (Blakers *et al.* 1984; Barrett *et al.* 2003; Birds Australia Nest Record Scheme, unpubl. data). The Red-whiskered Bulbul became common and widespread in suburban areas of Sydney in the 1920's (MacPherson 1923; Chisholm 1926; Fig. 4). Flocks of up to 100 were recorded in winter in the early 1930's (Chaffer 1933).



**Figure 4.** The spread of the Red-whiskered Bulbul *Pycnonotus jocosus* in the Greater Sydney Region based on available published literature.



**Figure 5.** Established populations of the Red-whiskered Bulbul *Pycnonotus jocosus* in Australia (dark grey), and areas where populations did not persist or outlying sightings were recorded (light grey).

By 1950, the population had spread to up to 100 km from the Sydney central business district (Lever 2010), reaching the Illawarra (Tarr 1950; Gibson 1977) and adjacent semi-rural areas such as southwestern Sydney (Frith 1979; Fig. 4). The first known sighting in the Camden district was recorded in 1956 (Gibson 1977). By the 1960's, the Red-whiskered Bulbul had spread across a radius of approximately 150 km of Sydney. During this time, individuals were being located in the Blue Mountains (Vallenga 1968; Smith and Smith 1990), with sightings occurring in the upper mountains (e.g., Mount Wilson in 1972) within 10 years (A.J. Leishman, unpubl. data).

Frith (1979) suggested that despite abundance in suburbia and colonisation of semi-rural districts, the Red-whiskered Bulbul would not be able to expand its range further north of Sydney due to low fruit abundance in the dry sandstone gullies and sclerophyll forests of the Hunter region. Nevertheless, sightings were recorded in Kincumber and Tumby Umbi in 1973, the earliest known records in the Hunter region (Morris 1975). The Red-whiskered Bulbul became established in the lower Hunter region within ten years (Blakers *et al.* 1984). It also reached the Shoalhaven River in the south by the 1980's and Lake Wollumbolla in

the 1990's (Higgins *et al.* 2006; Birdlife Australia, unpubl. data; Fig. 4). The development of peri-urban districts appeared to support local population growth, for example in Campbelltown in 1992, during the establishment of several major housing estates (Leishman 1994).

#### *Northern Rivers region, New South Wales*

An established population in Coffs Harbour (Fig. 5) was first noticed in 1972 (Higgins *et al.* 2006), presumably introduced not long prior. The range of this population has slowly expanded south to Sawtell and inland to Bellingen over 15 years (Morris *et al.* 1981; Blakers *et al.* 1984; Birdlife Australia, unpubl. data), reaching Moonee Beach in the north in 2000 (Barrett *et al.* 2003). Observations of breeding in Coffs Harbour were recorded by bird observers as early as the 1970's (Blakers *et al.* 1984; Barrett *et al.* 2003; Birds Australia Nest Record Scheme, unpubl. data)

#### **Mackay, Queensland**

Sightings of the Red-whiskered Bulbul began in Mackay, Queensland (Fig. 5) in September 1983 (Crouther 1984; I. Gynther, unpubl. data). Further observations confirmed a small breeding population had established (Barrett *et al.* 2003; Higgins *et al.* 2006).

## Melbourne and surrounds, Victoria

Red-whiskered Bulbuls were first recorded in Victoria in Ashfield, a suburban location in Melbourne in 1915 (Lever 2010; Fig. 5). There were also sightings in the Melbourne Botanical Gardens (Long 1981). Lendon (1952) challenged whether reports from this time period were entirely of Red-whiskered Bulbuls. Lendon (1952) located a preserved specimen of a Red-vented Bulbul at the South Australian Museum that was collected in Toorak, Melbourne in 1918 and reported a free-living Red-vented Bulbul in Melbourne in 1942. Other authors located Red-whiskered Bulbuls in parts of Melbourne and Geelong in the 1940's (Chisholm 1950; Tarr 1950; Pescott 1983). These records include two pairs of Red-whiskered Bulbuls observed in Toorak (Tarr 1950), where some specimens were collected in the 1910's. The population in Melbourne was believed to have established in the late 1950's (Lever 2010).

## Adelaide, South Australia

There have been historical records in Adelaide (Fig. 5) since the mid-1940's (Lendon 1944), including at least one confirmed sighting in North Adelaide in December 1943. Red-whiskered Bulbuls were also reported in Westbourne Park between 1944 and 1945 (Terrill 1946). Long (1981) regarded Red-whiskered Bulbuls to be common in Adelaide during this time period, but this was disputed by Paton (1985). Tarr (1950) was aware of local reports, but did not believe any population had established. This was apparently correct as sightings discontinued until the 1970's. Paton (1985) warned that bird observers rarely included escaped species in their published lists, so that a lack of records did not mean that no sightings occurred. Condon (1962) stated that Red-whiskered Bulbuls in Adelaide were more likely to be aviary escapees (Condon 1962). At least some deliberate releases are known (Storr and Delroy 1979; Nagel 1979).

There were further reports in Adelaide in the late 1970's and early 1980's (Paton 1985). Seven Red-whiskered Bulbuls were released near Hackham where they were located by Storr and Delroy (1979) in March 1979. The owner recaptured six individuals by using a captive specimen to attract them by calling (Nagel 1979). This action was prompted by a request from the Avicultural Society of South Australia.

A number of sightings were recorded in the Mount Lofty Ranges; one individual in Stirling in January 1980 (Paton 1985), one individual in Waterfall Gully in October 1980 (Brune 1980), a pair in Beaumont in October 1981, and one individual in Waterfall Gully, sighted on numerous occasions in January 1982 (Brune 1982). Some of these individuals had been seen feeding on blackberries (Paton 1985) and solanum *Solanum* sp. fruits from gardens (Brune 1980). Sightings were also recorded from the suburbs of Gilbert, Unley Park, Port Adelaide and Moana (South Australian Ornithological Association, unpubl. data).

A pair successfully bred in an open shade house in Enfield in December 1983, producing four fledglings (Barrington 1985). The bulbuls were feeding on strawberries and raspberries in the vicinity. Five individuals were exterminated by officers of the Law Enforcement Section,

South Australian National Parks and Wildlife Service. One fledgling was captured alive in a mist-net and was retained as a captive bird to be used to draw in other Red-whiskered Bulbuls in future trapping operations.

## Murray Bridge, South Australia

There was apparently a small population existing in Murray Bridge between 1979 and 1983 (Fig. 5). In December 1979, a Red-whiskered Bulbul feeding on apricots was shot by Pedler (1980). This female specimen is now preserved at the South Australian Museum (registration number, B 32582) (Jaensch and Joseph 1980; Paton 1985). A pair was also located in Murray Bridge in July 1983 (Filsell 1983; Glover 1983).

## Outlying locations

There have been at least ten sightings of the Red-whiskered Bulbul in areas that are isolated from the regions detailed above (Fig. 5). In May 1977, there was a sighting in Morwell (Blakers *et al.* 1984), situated at least 70 km from the established population in Melbourne. There was a sighting in Tallebudgera Creek, Queensland in February 1991 (Queensland Ornithological Society, unpubl. data). The only known sighting of a Red-whiskered Bulbul in Western Australia was recorded in Safety Bay in August 1993 (Higgins *et al.* 2006).

One individual was located in Dripstone in the Central West region of New South Wales in the 1930's (Althofer 1934). Other sightings in New South Wales include one in Yamba in 1981 (Blakers *et al.* 1984), an unconfirmed report in Lismore in 1984 (Queensland Ornithological Society, unpubl. data), and one in South West Rocks in 1999 (Birdlife Australia, unpubl. data). The Red-whiskered Bulbul has also been recorded a few times in Forster (Higgins *et al.* 2006). There have also been a small number of sightings distributed across the Southern Tablelands and the Australian Capital Territory (Higgins *et al.* 2006), including isolated records in Canberra in May 1993 (Wilson 1993) and Lake George in February 1999 (Nix 1999). There was one outlying sighting in Deniliquin in September 1980 (Blakers *et al.* 1984).

## Current status

There are four extant populations of the Red-whiskered Bulbul in Australia: established populations in the Greater Sydney Region and the Northern Rivers region, New South Wales, Mackay, northern Queensland, and Melbourne, Victoria (Fig. 5). There has been no published information of occurrence in South Australia since Paton (1985).

The current extent of the population in the Greater Sydney Region extends as far north as Seaham and Raymond Terrace in the Hunter region (Blakers *et al.* 1984; Pizzey *et al.* 2007). The western extremities lie at the Blue Mountains and Goulburn River National Park (Hardy and Farrell 1990; Smith and Smith 1990; Fulton 2002). The population continues south to the Lake Wollumboola in the Shoalhaven region (Wood 1996; Chafer *et al.* 1999; Barrett *et al.* 2003). Wood (1995) determined population densities of up to 4.17 individuals per ha in

Puckeys Reserve, near Wollongong. The population has also invaded semi-rural districts, especially in orchards (Gibson 1977; Frith 1979; Chafer *et al.* 1999). Since 2010, there have been 3703 database records attributed to the Greater Sydney Region population (ALA 2015).

The population in the Northern Rivers region has persisted since its first detection in 1972 (Barrett *et al.* 2003; Owner 2009). Coffs Harbour remains the focus of this population (Pizzey *et al.* 2007). The Mackay population has also persisted, but has not expanded since detection in 1983 (Barrett *et al.* 2003; Higgins *et al.* 2006). Since 2010, the Northern Rivers and Mackay populations have been represented by eight and 28 database records respectively (ALA 2015).

The Melbourne population has been established since the 1950's (Lever 2010). Here, Red-whiskered Bulbuls have since been recorded within a range of Dandenong in the southeast, Boronia to the east, Watsonia to the northeast and Oak Park to the northwest (Blakers *et al.* 1984; Emison *et al.* 1987; Barrett *et al.* 2003; Bird Observers Club Australia, unpubl. data). Pizzey *et al.* (2007) listed the suburbs of Banyule, Ivanhoe, Kew and St Kilda as likely locations to obtain sightings. Since 2010, there have been 17 database records attributed to this population (ALA 2015).

Interestingly, the Red-whiskered Bulbul occurs in natural bushland to some extent in Australia, unlike in Florida (Holt 1989; Pranty 2010). There have been some situations where establishment has occurred in thickets and forested gullies (Morris 1975, 1986; Leishman 1994; Lever 2010), usually close to the boundaries between natural area and urban settlement. Wood (1995) recorded the Red-whiskered Bulbul in eucalypt-banksia forest, casuarina forest and sedgeland in an urban reserve in Wollongong. In the Blue Mountains, individuals resided in an open forest dominated by eucalypts *Eucalyptus* spp. and *Angophora* spp. with low shrubbery, and a warm temperate rainforest dominated by Yellow Sassafras *Doryphora sassafras* and Coachwood *Ceratopetalum apetalum*, both immediately adjacent to planted gardens (Fulton 2002). In southern Sydney, Red-whiskered Bulbuls residing in remnant bushland appear to be largely restricted to riparian areas (pers. obs; D.R. Waterhouse and J. Cockayne, pers. comm), as reported in other countries (Hardy 1973; Techachoochert and Round 2013).

## Potential and realised ecological impacts

### Spread of weeds

The main environmental concern posed by the naturalisation of the Red-whiskered Bulbul has been the dispersion of invasive weeds. There have been studies to confirm this in Japan (Eguchi and Amano 2004), Florida (Carleton and Owre 1975), Mauritius (Vaughan and Wiehè 1939; Cheke 1987; Strahm 1999; Linnebjerg *et al.* 2009, 2010) and Réunion Island (MacDonald *et al.* 1991; Lavergne *et al.* 1999; Mandon-Dalger *et al.* 2004; C. Thébaud, unpubl. data). In Australia, it has been implicated in the establishment of African Olive in western Sydney

(NSW NPWS 1997; Cuneo and Leishman 2006). Authors have also reported it feeding on noxious weed species such as Lantana *Lantana camara* (Chaffer 1933, 1945; Morris 1986, 1989; Wood 1996, 1999), Blackberry (Paton 1985; Morris 1986), Inkweed *Phytolacca octandra* (Chaffer 1933), Bitou Bush *Chrysanthemoides monilifera* (Gosper 1999) and Small-leaved Privet *Ligustrum sinense* (Gannon 1932; Chaffer 1933; Pizzey *et al.* 2007). In Sydney, I have noticed that areas inhabited by the Red-whiskered Bulbul tend to be host to one or more of these exotic weeds.

### Interspecific competition and predation

There have been some reports of the Red-whiskered Bulbul competing with native species. This would only be significant in disturbed environments due to its current status (DECC 2007). Concerns over interspecific competition would be most relevant to invasions of islands, for example, the Mascarene Islands (Jones 1996; Philippe and Mandon-Dalger 2001); natural processes on islands are more vulnerable to disturbance by function of reduced land mass (Reaser *et al.* 2007; Fritts and Rodda 1998). The Red-whiskered Bulbul was believed to have contributed to population declines of white-eyes *Zosterops* spp. in Mauritius (Cheke 1987; Sørensen 2005). In addition, on some Nicobar Islands, it has displaced the Nicobar Bulbul *Hypsipetes nicobariensis* (Sankaran 1998). In Australia, the Red-whiskered Bulbul may be aggressive to other bird species, either defensively (Wood 1999) or in competition for resources. One author observed agonistic responses toward flocks of Silvereyes *Zosterops lateralis* and rosellas *Platycercus* spp. feeding on Camphor Laurel *Cinnamomum camphora* fruits in Sydney (MacPherson 1923). Despite these observations, there is no evidence that interspecific competition in Australia is ecologically significant.

There has been limited study of the impact of predation by Red-whiskered Bulbul on arthropod abundance. Its presence in Mauritius has been attributed to an extirpation in golden orb-weaving spiders *Nephila* spp. (Islam and Williams 2000). Such an impact possibly has an indirect effect on native predators. There have also been some claims of attacks on young endemic birds on the Mascarene Islands (Philippe and Mandon-Dalger 2001; Baker *et al.* 2014) and Assumption Island, Aldabra (Roberts 1988). There has been at least one record of Red-whiskered Bulbuls causing deaths of other birds in a mixed-species aviary (Chaffer 1933).

At least one Australian species has positively interacted with the Red-whiskered Bulbul. A number of authors have observed the Pallid Cuckoo *Cacomantis pallidus*, a parasitic bird, exploiting its breeding attempts (Marshall 1931; Chaffer 1945; Gregory-Smith 1983; Blakers *et al.* 1984; W.E. Boles, unpubl. data).

### Social impacts

Responses to the Red-whiskered Bulbul have been mixed. It was considered a pest in Australia as early as the 1920's, causing damage to peas, figs and strawberries in Sydney gardens (MacPherson 1923). The Red-whiskered Bulbul also causes crop failure in soft-fruit and citrus orchards (Chaffer 1933; Frith 1979), as it has in California (Islam

and Williams 2000) and Hawaii (Williams and Giddings 1984), although the economic impact has not been properly quantified. In response, one man was said to have culled 240 individuals (Higgins *et al.* 2006). On the contrary, it preys on garden-damaging insects such as aphids (MacPherson 1923; Chisholm 1926), as well as larvae of the Grapevine Moth *Phalaenoides glycinae*, which few native birds prey on (Chaffer 1933; Chisholm 1933; Frith 1979; Gregory-Smith 1983). It is also an aesthetically attractive species, with at least one author calling for its protection (Chisholm 1933).

## Conclusion

Australia has a long history of invasive species (Bleach *et al.* 2014; Cooke 2014; Mutze *et al.* 2014). A recent review by Baker *et al.* (2014) found there was little evidence that introduced birds pose a threat to native avifauna. The Red-whiskered Bulbul is one of at least 27 species of exotic birds in Australia, which based on current literature and unpublished databases, do not appear to have as damaging an impact as the Common Myna *Acridotheres tristis* and Common Starling *Sturnus vulgaris* (Tracey *et al.* 2007; Owner 2009; Grarock *et al.* 2014; Old *et al.* 2014). Both the myna and starling affect breeding success in some parrot species through competition for nest hollows (Pell and Tidemann 1997), and the starling has an serious impact on agriculture, especially vineyards and orchards (Tracey and Saunders 2003). Although at least one author has suggested not controlling the Red-whiskered Bulbul in light of its apparently low impact (Chisholm 1933), authorities in South Australia and Western Australia have exterminated reported individuals, effectively preventing any population establishment, solely for the protection of fruit crops (Barrington 1985; Paton 1985; Higgins *et al.* 2006).

To justify the investment of an eradication program, it would be appropriate to better understand the impacts of the Red-whiskered Bulbul on the ecology of Australian flora and fauna. Its role in spreading weed species has received some global attention (Carleton and Owre 1975; MacDonald *et al.* 1991; Lavergne *et al.* 1999; Strahm 1999; Eguchi and Amano 2004; Mandon-Dalger *et al.* 2004; Linnebjerg *et al.* 2009, 2010). Evidence in Australia remains

largely anecdotal (Chaffer 1933, 1945; Paton 1985; Morris 1986, 1989; Wood 1996, 1999; NSW NPWS 1997; Gosper 1999; Cuneo and Leishman 2006; Pizzey *et al.* 2007). Although its role in interspecific competition and prey reduction has been shown in island environments (Jones 1996; Cheke 1987; Sankaran 1998; Islam and Williams 2000; Philippe and Mandon-Dalger 2001; Sørensen 2005), there have not been formal studies of these impacts in Australia. Reports of predation on nestling birds have been few (Roberts 1988; Philippe and Mandon-Dalger 2001) and not reflected in any dietary studies (Carleton and Owre 1975; Xiaohua 1992; Corlett 1998; Linnebjerg *et al.* 2010). These impacts should be assessed by further research, especially focused and with case-specific studies, to provide direction on management actions.

The Red-whiskered Bulbul has declined in parts of its endemic range due to trapping for the commercial bird industry (del Hoyo *et al.* 2005; Techachoochert and Round 2013). While this is a significant concern, it offers hope for controlling introduced populations. Recently, eradication has been successful on the island of Assumption (Bunbury *et al.* 2013; Michel 2015) despite a large established population (Roberts 1988; Hill and Currie 2007). On Réunion Island, 424 individuals were trapped in cages baited with fruit and conspecifics between July 2002 and January 2003 (Mandon-Dalger 2002; Amiot *et al.* 2007). Eradication of exotic fauna on the Australian mainland has historically been unrealistic (Bayliss *et al.* 1989; Calver *et al.* 1998; Campbell and Donlan 2005). However, eradication of the Red-whiskered Bulbul in mainland Australia may be achievable since the populations are mostly restricted to 'islands' within areas of human settlement.

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